



Enhanced Storm Investigation - 2015

National Weather Service
Milwaukee/Sullivan, WI

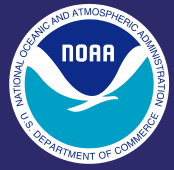
www.weather.gov/mkx



www.facebook.com/NWSMilwaukee



twitter.com/NWSMKX



Convection Basics



- Moisture
- Instability
- Lift
- Wind Shear (for severe storms)





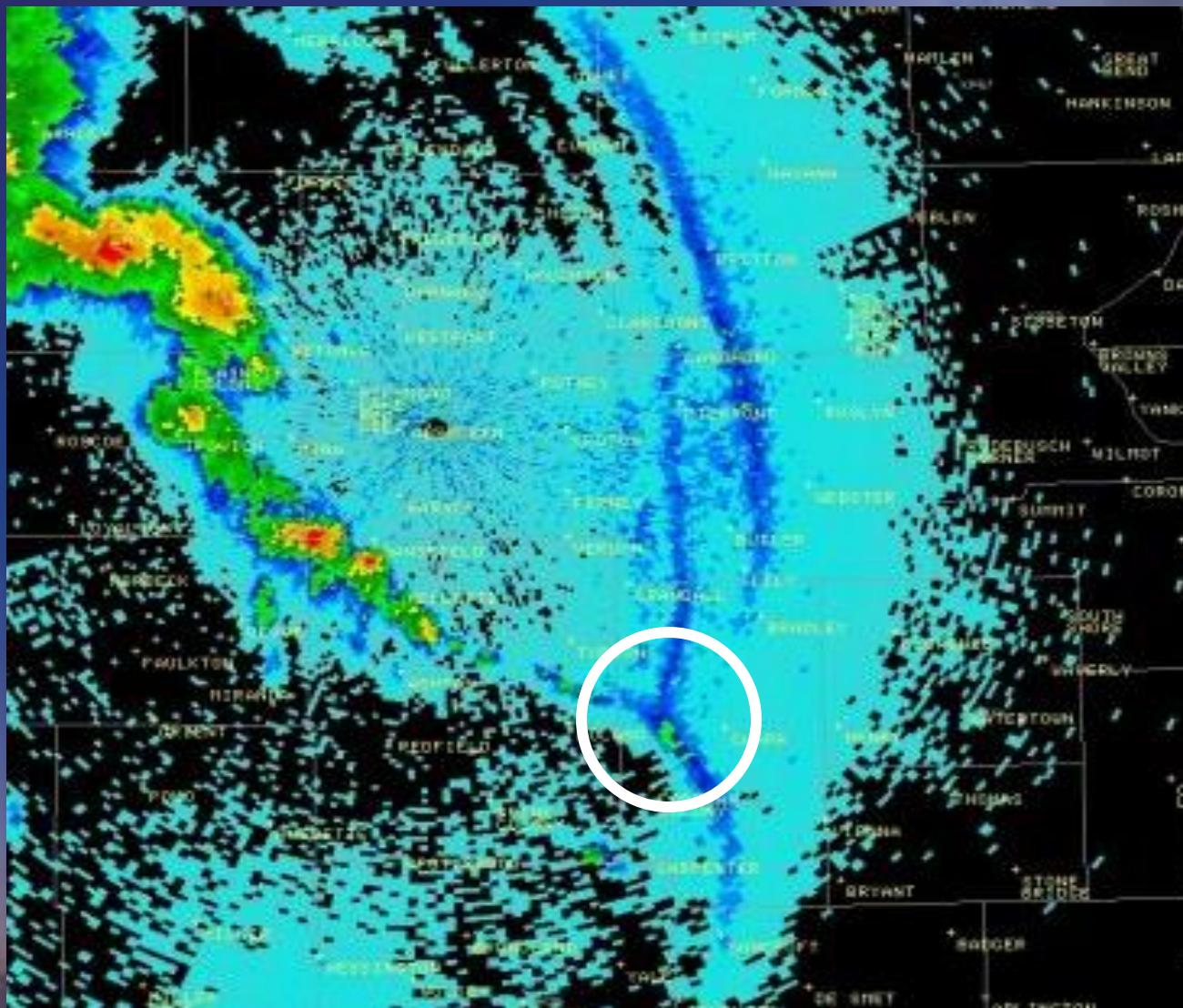
“Triggering” Mechanisms

- **Can initiate thunderstorms...**
 - *Low pressure systems/Jets*
 - *Air mass boundaries, Fronts*
 - *Sea/Lake Breeze*
 - *Thunderstorm ‘outflow boundaries’*
 - *Orographic lift*

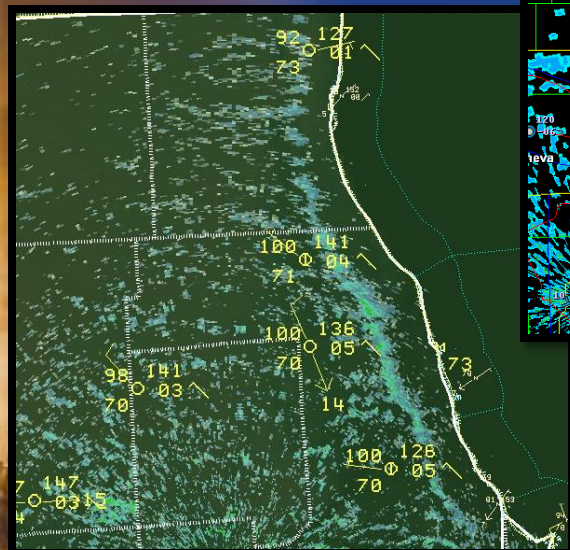
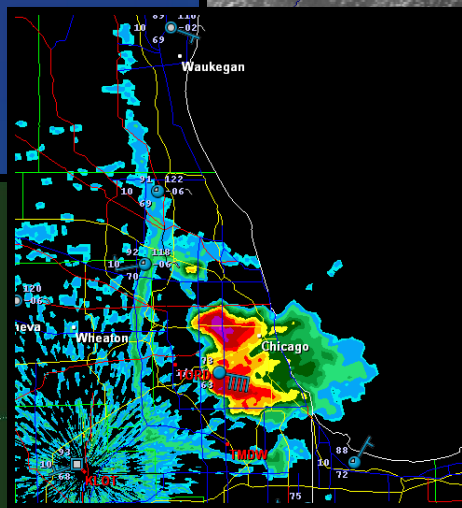
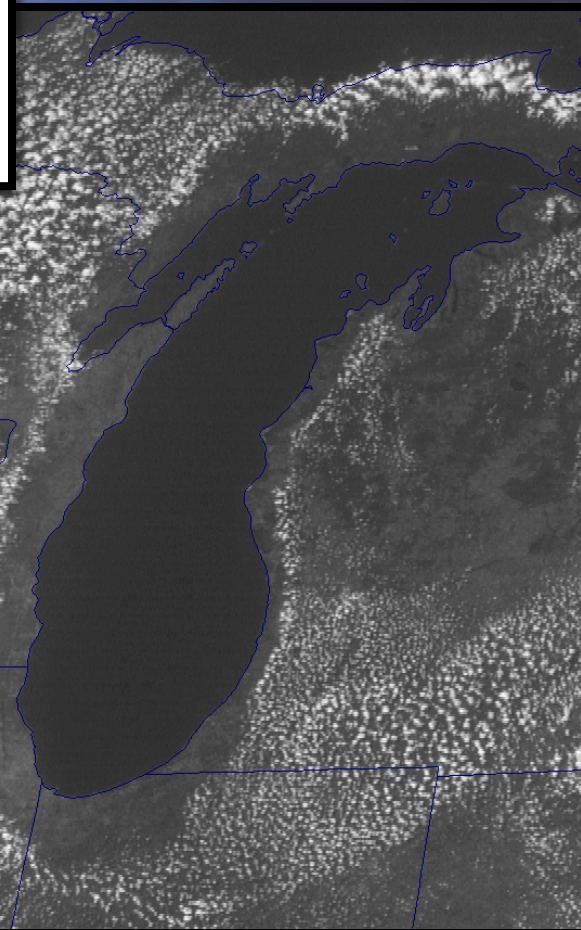
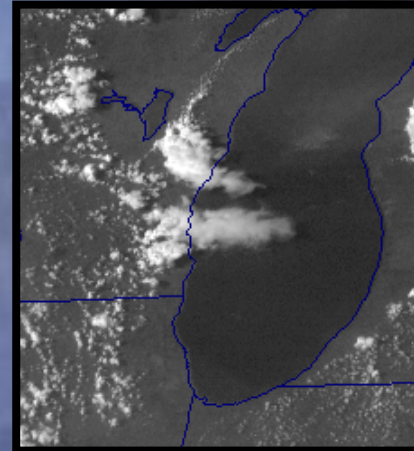
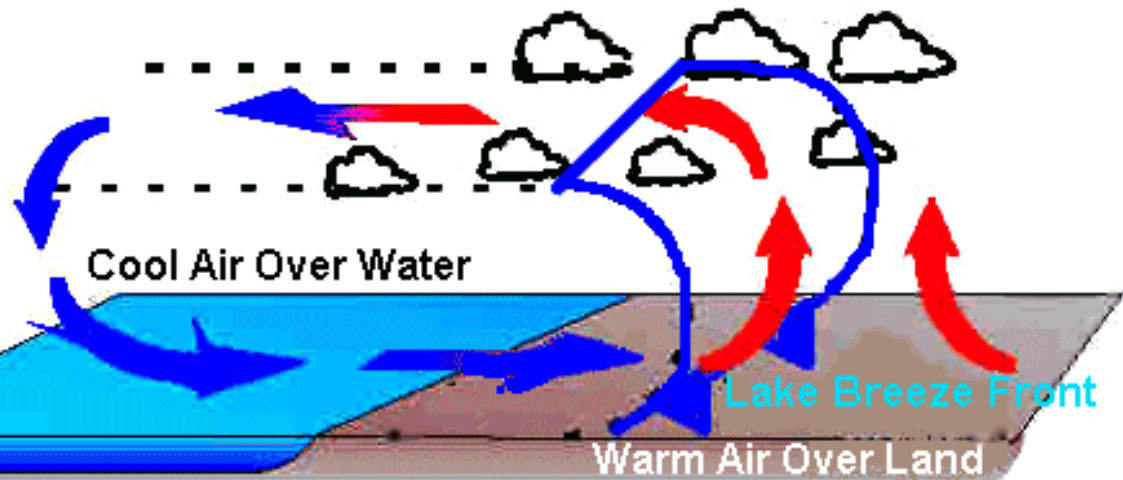




Thunderstorm Outflow Boundaries



Lake Breeze Circulation



Four Types of Thunderstorms

Single
Cell

Multicell
Cluster

Multicell
Line

Supercell

Weak updraft
(non-severe
or severe)

Moderate
updraft (non-
severe
or severe)

Moderate
updraft (non-
severe
or severe)

Intense updraft
(Always severe)

**Mesocyclone -
Rotating updraft**

Slight threat

*Moderate
threat*

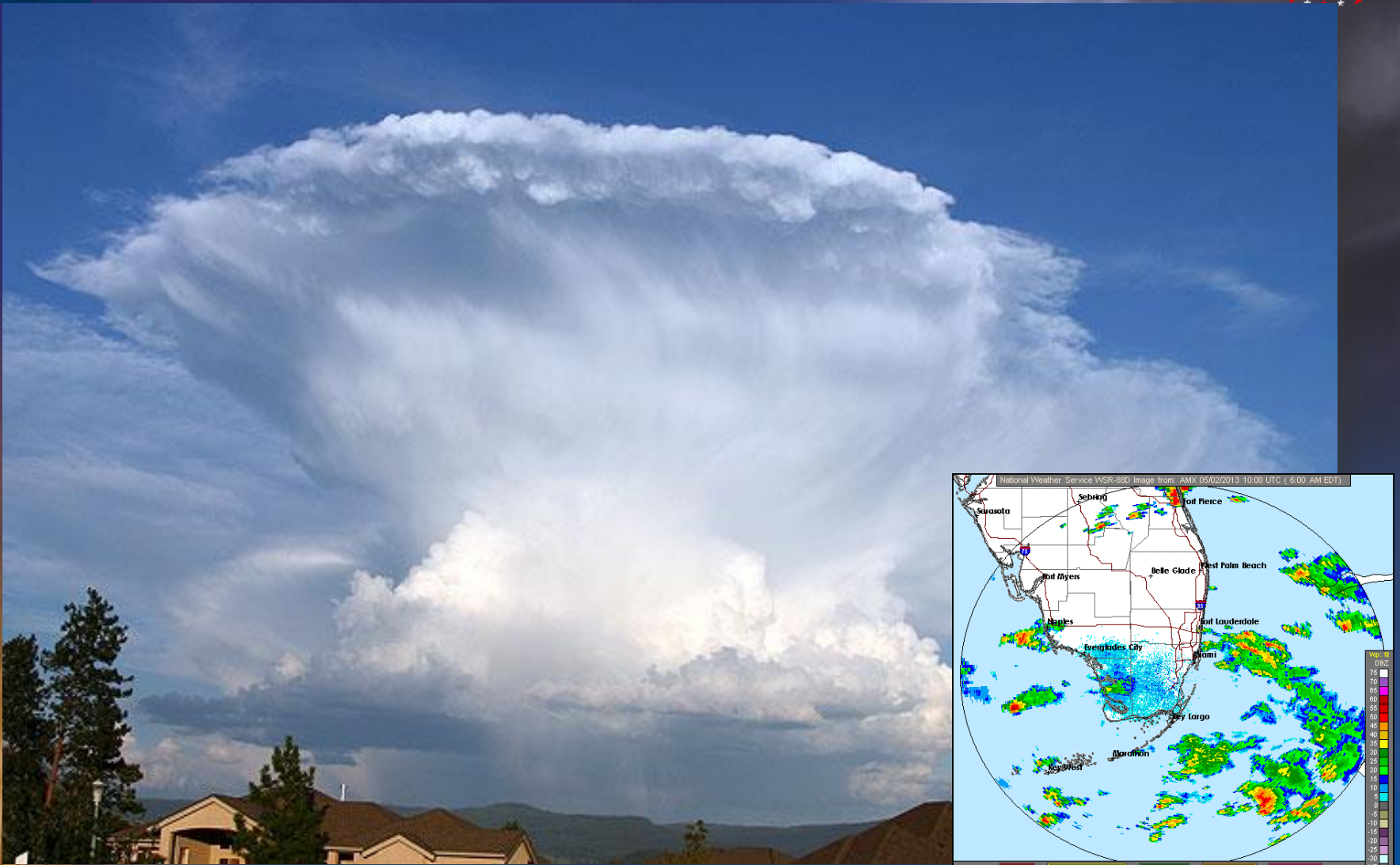
*Moderate
threat*

High threat





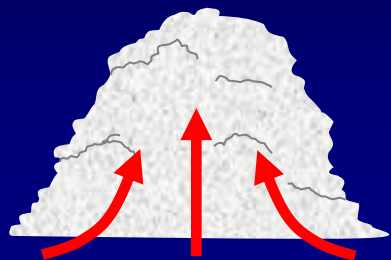
Single Cell Storms



May produce brief severe weather



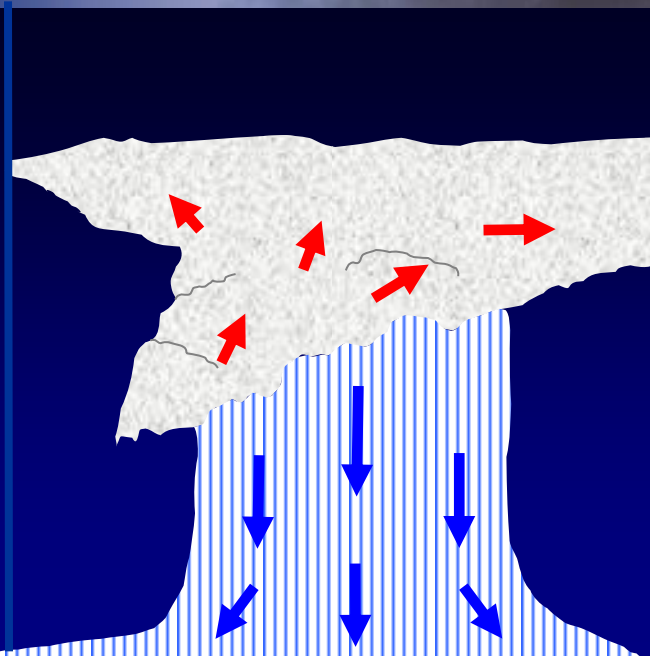
Thunderstorm Life Cycle



Cumulus Stage



Mature Stage



Dissipation Stage



©2001 Chris Kridler
skydiary.com

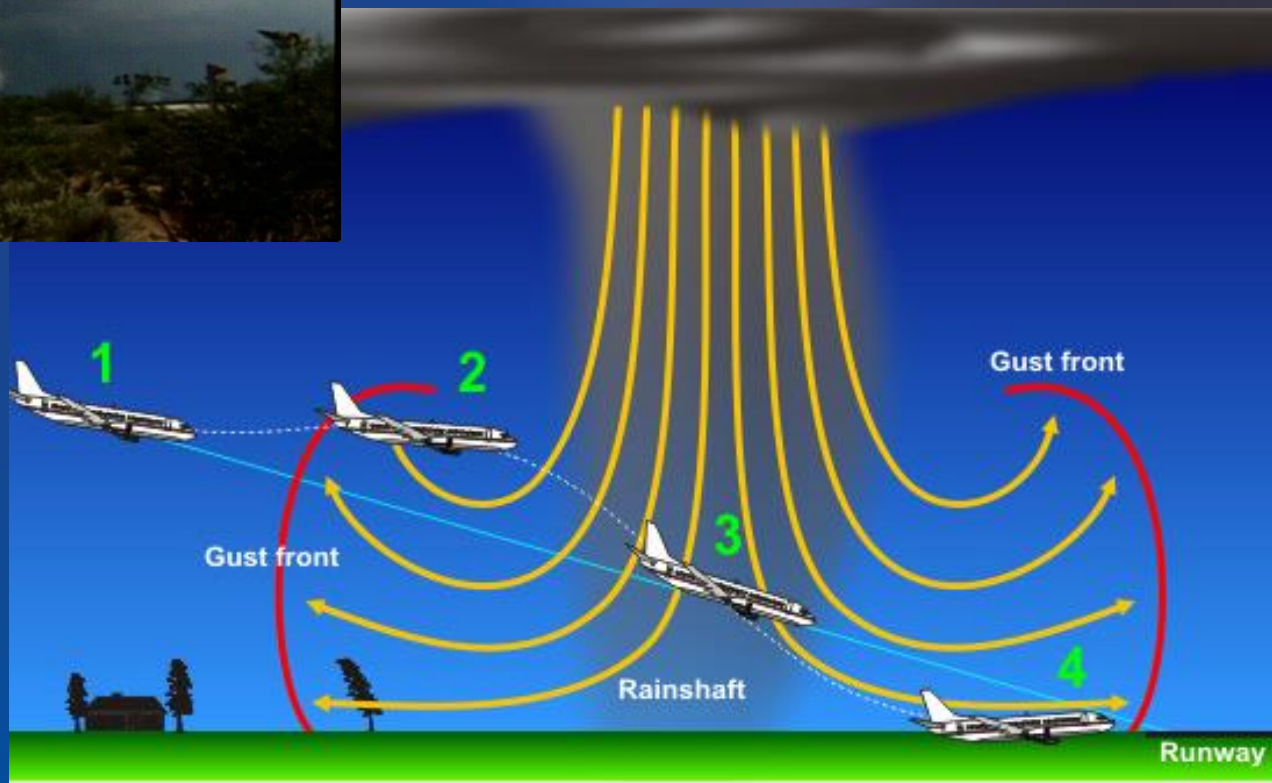




Downburst Winds



shelf cloud





Downburst Winds



Vic

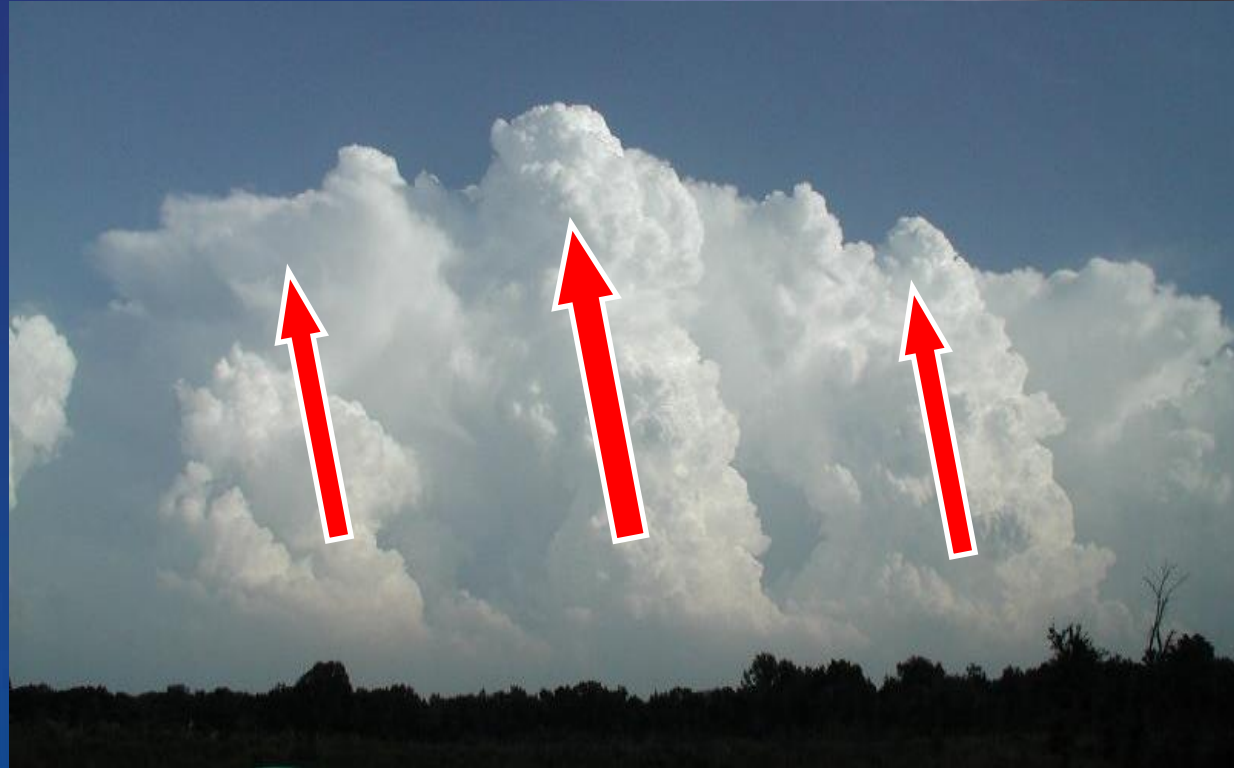


Multi-Cell Thunderstorms



Ordinary, non-organized storms with low severe threat

Each cell lasts 20-30 minutes, but a cluster can last for hours



Heavy rain is the main problem

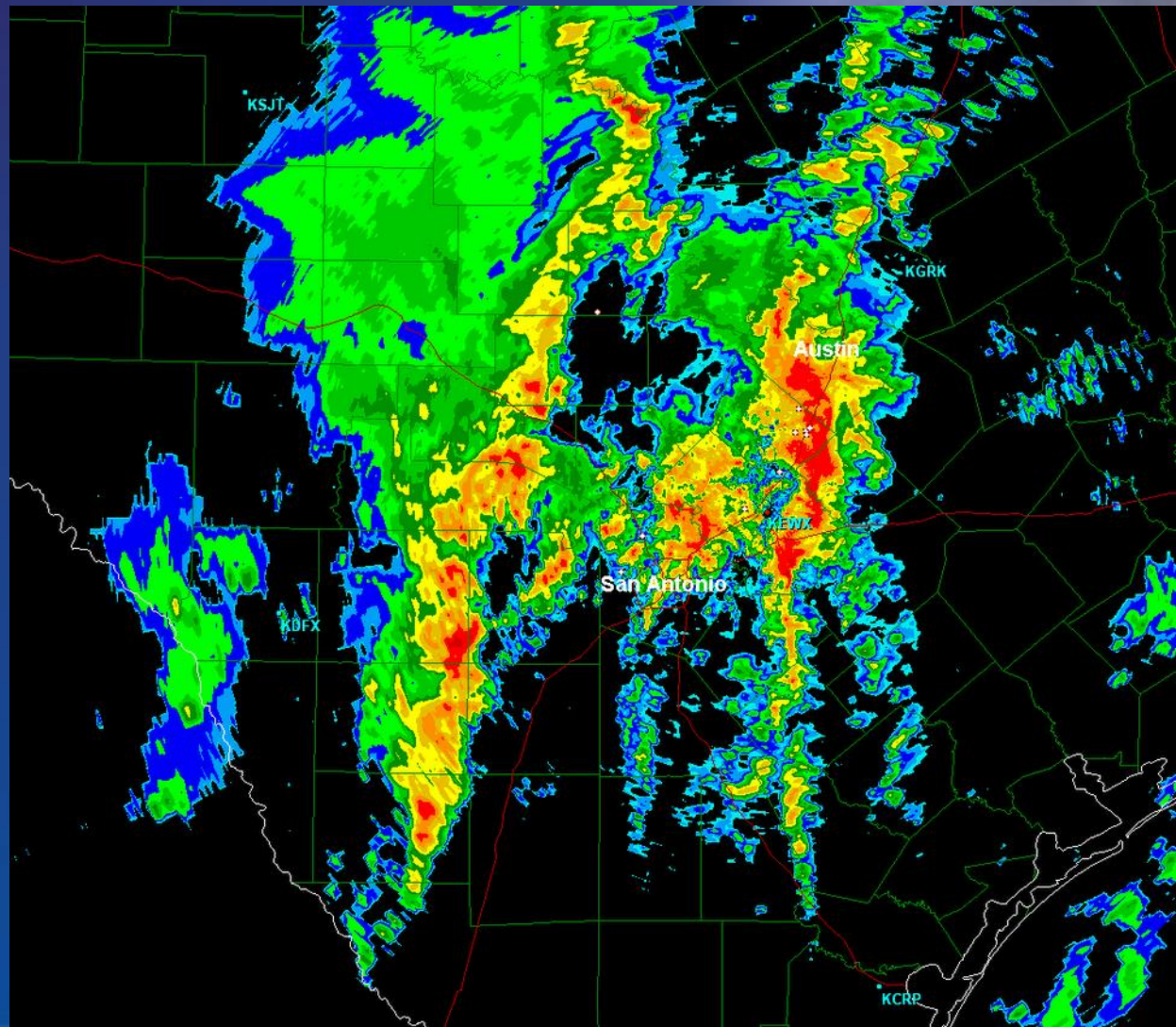
Strong winds, small hail and weak tornadoes are possible



Multi-Cell Thunderstorms



Ordinary, non-organized storms with low severe threat





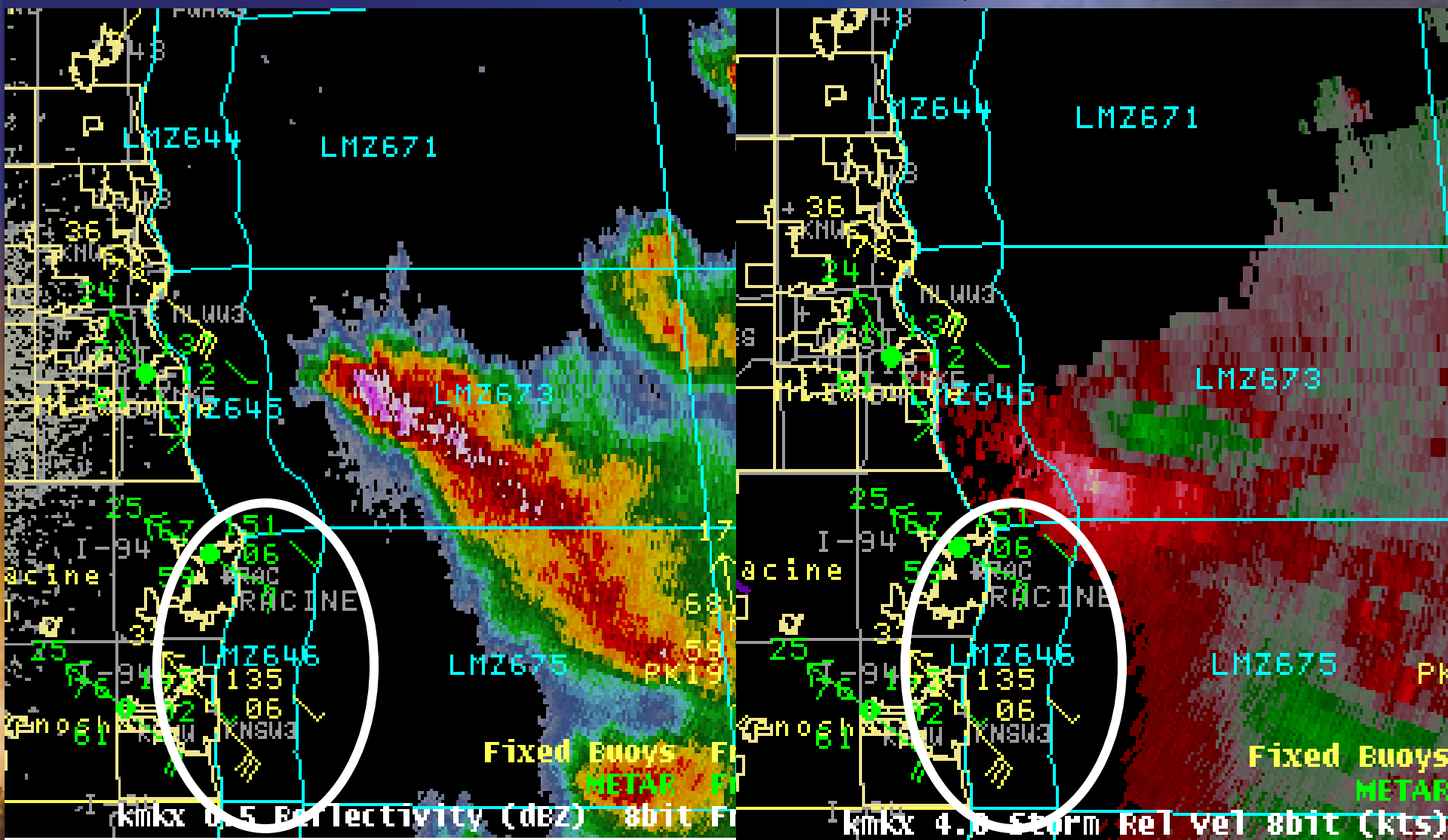
Straight-Line Wind Event Kenosha, June 30, 2011



Video

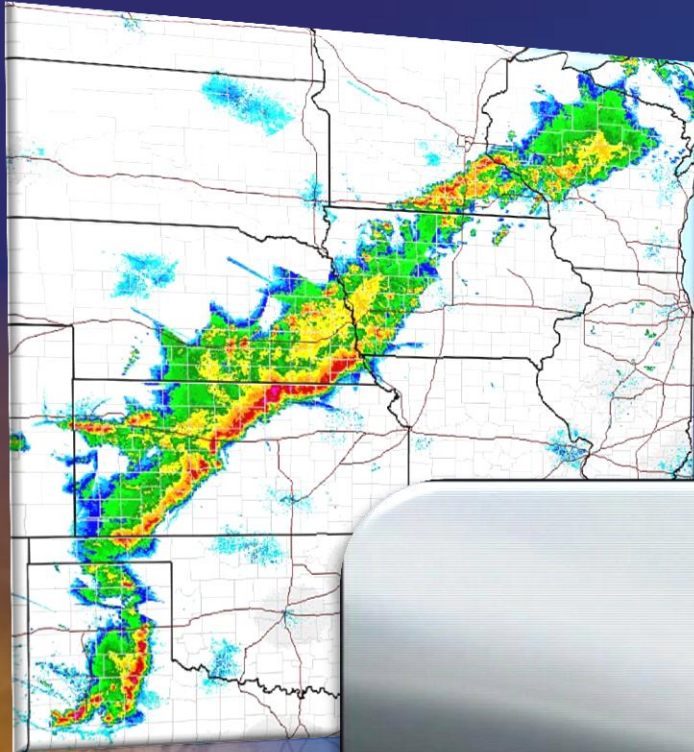


Straight-Line Wind Event Kenosha, June 30, 2011





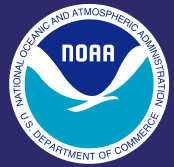
Multi-Cell (Squall) Line



- Leading edge of squall line usually marked by shelf cloud
- Do not report shelf clouds



- What to expect
 - *Strong and possibly damaging wind*
 - *Heavy rain/hail*



Squall Line - Bow Echo

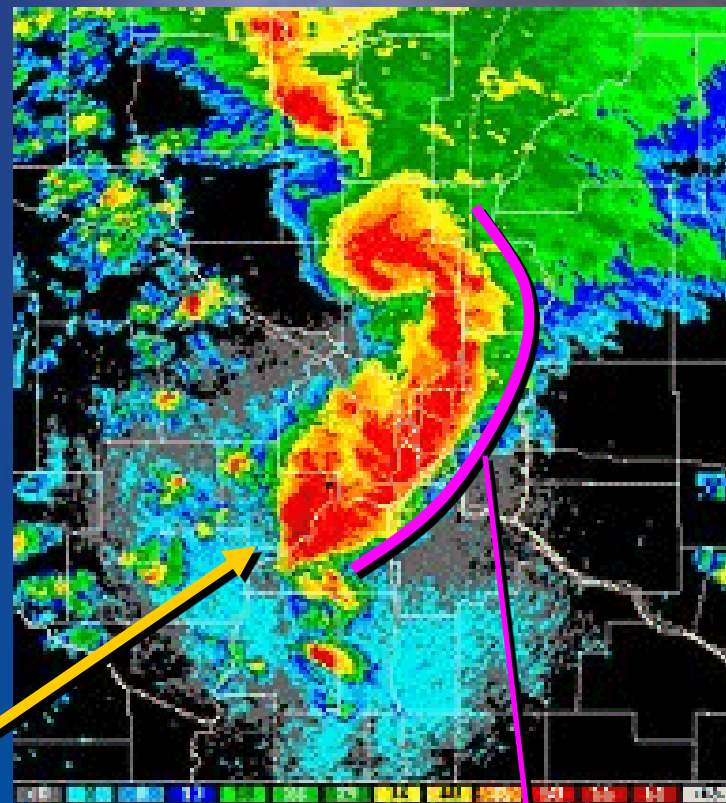


**This shelf cloud is ahead of
bow echo on right**



© 2001 Eric Nguyen

**Storm moving left
to right (W-E)**



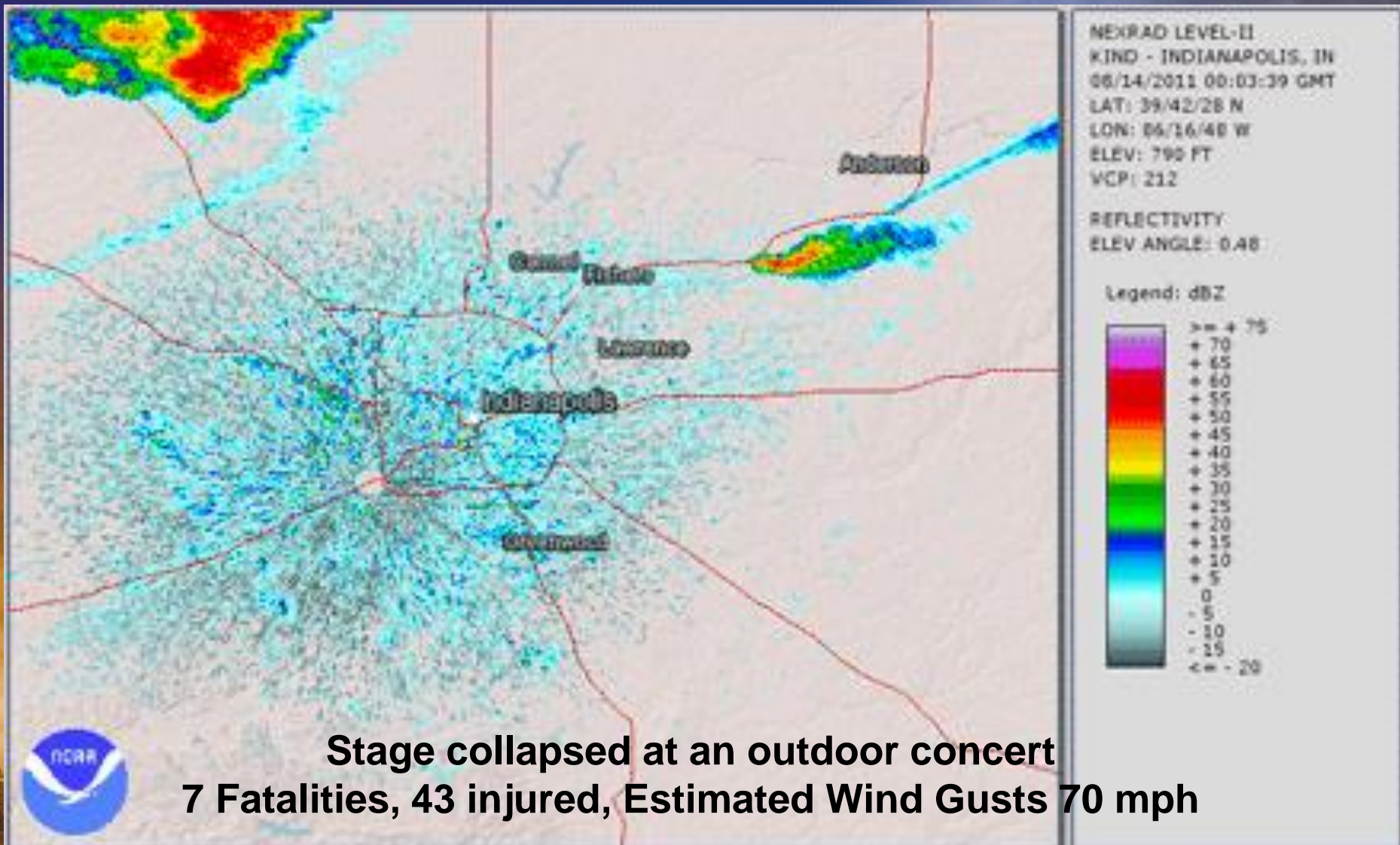
Well-developed shelf cloud is
found on front side of line

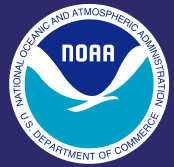
Shelf Cloud

Video



August 13, 2011 Indiana State Fair





Supercell Thunderstorm

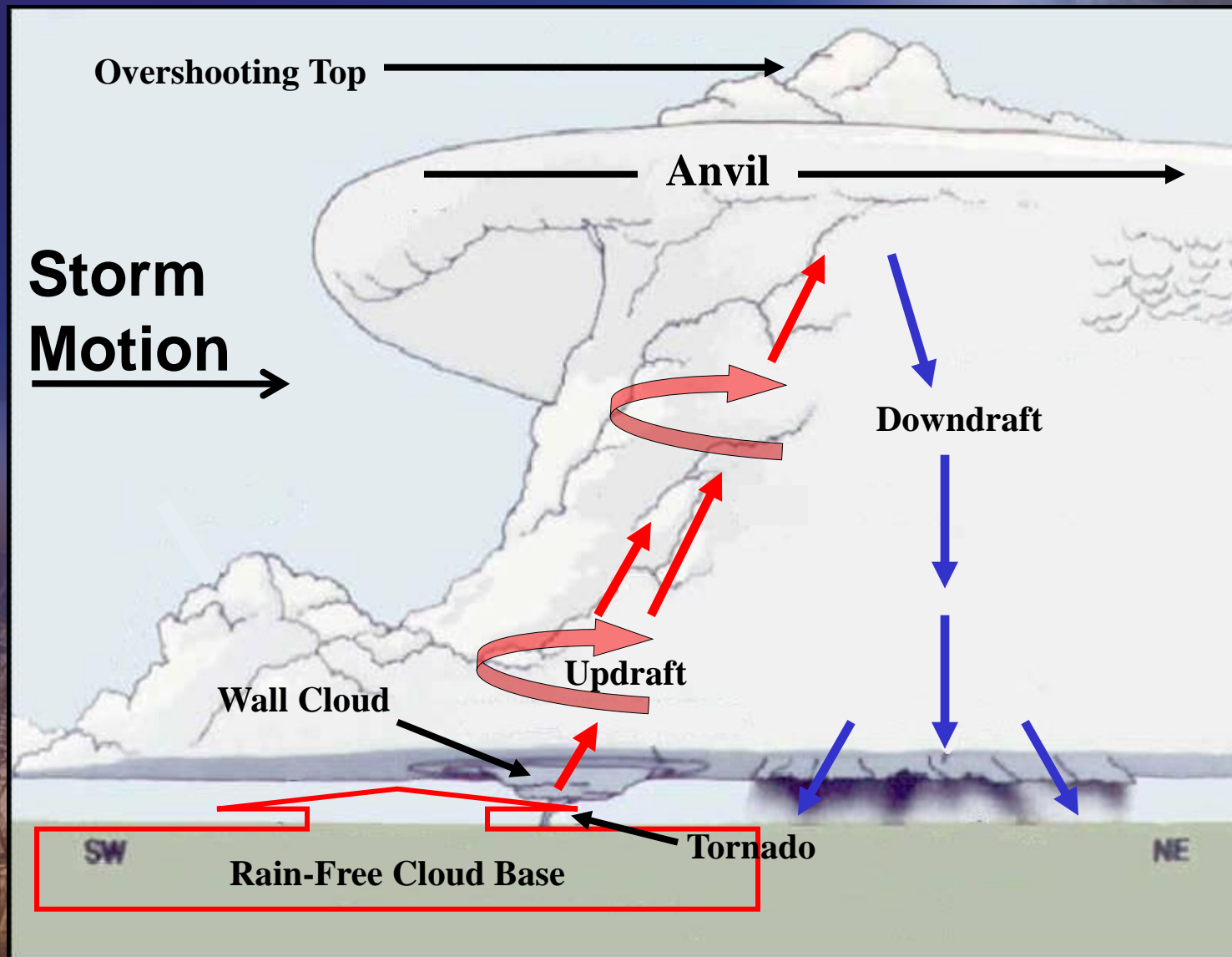


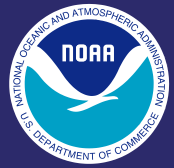
- Contains a rotating updraft called a mesocyclone
- Only about 10% of radar-detected meso's are associated with a tornado
- Produce large hail, high winds, and strong to violent tornadoes
- Can last for several hours





Supercell Structure





Rotation in Updraft Tower



Spiral bands and cork-screw look



Evaluating the Surroundings



A thick, crisp anvil (knuckles) is another sign of a strong updraft

Hard-crisp appearance is indication of a rapidly, intensifying storm!



Storm Strength Clues

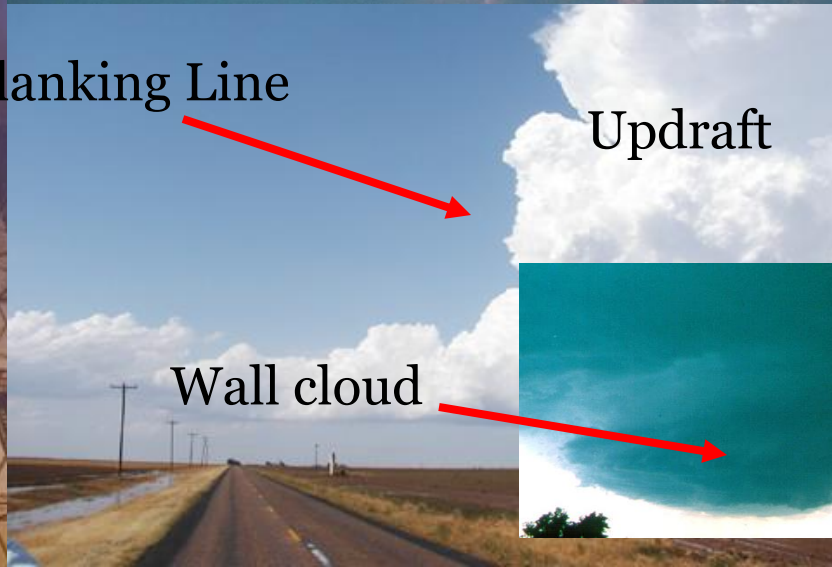


Overshooting Top

Flanking Line

Updraft

Wall cloud





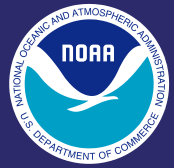
Rotating Wall Clouds

An isolated lowering of the rain-free base, rotating on a vertical axis



@2005 Frank Weisensel

A good number of, but not all, tornadoes develop underneath or near a rotating wall cloud



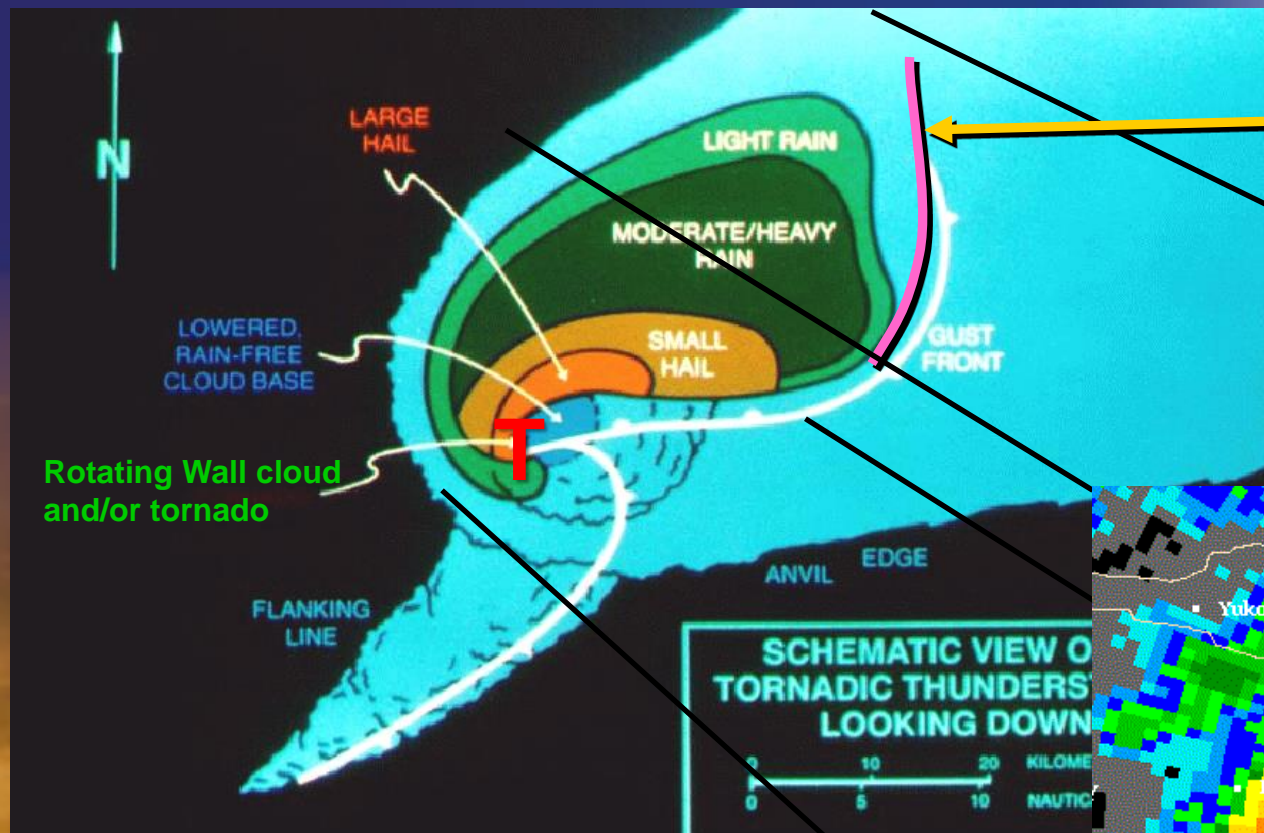
Rotating Wall Cloud



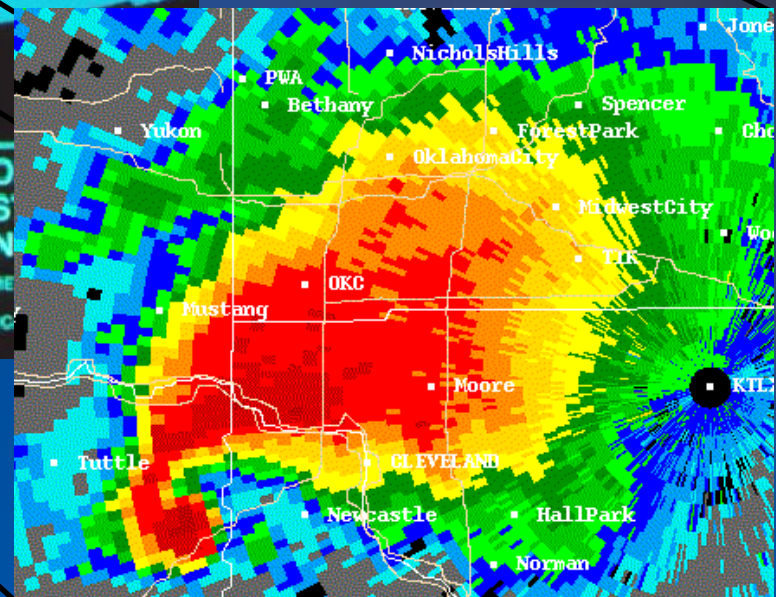


Tornadic Supercell Thunderstorm

top-down view



Shelf
Cloud



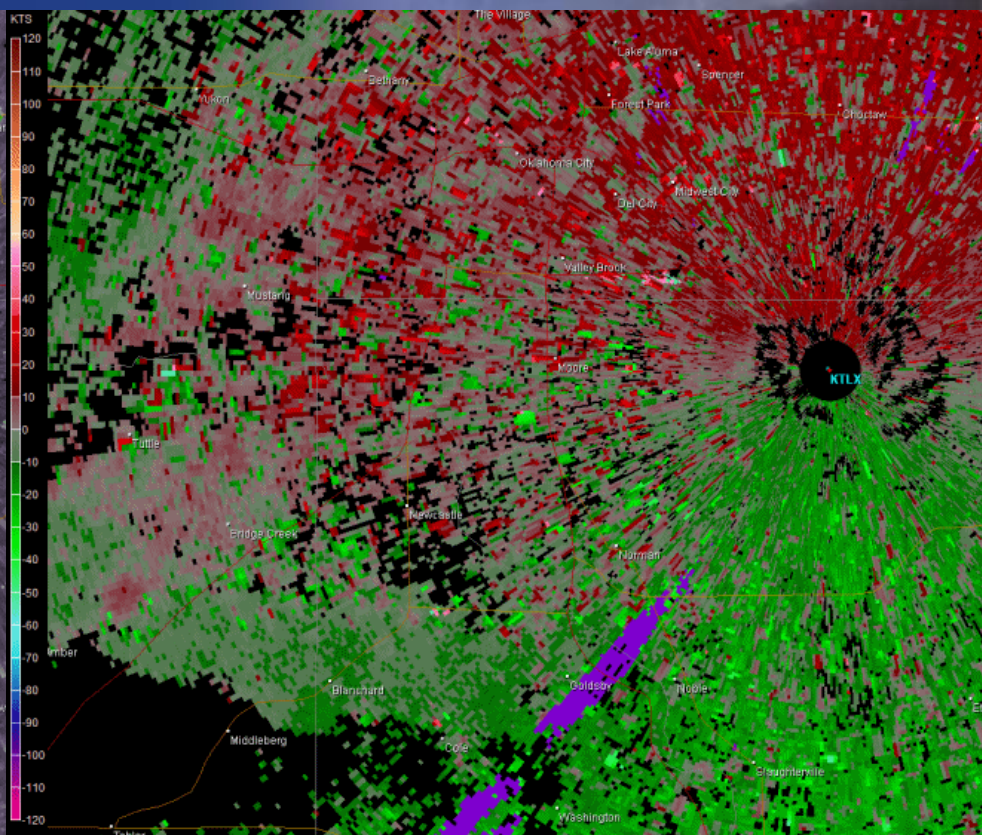
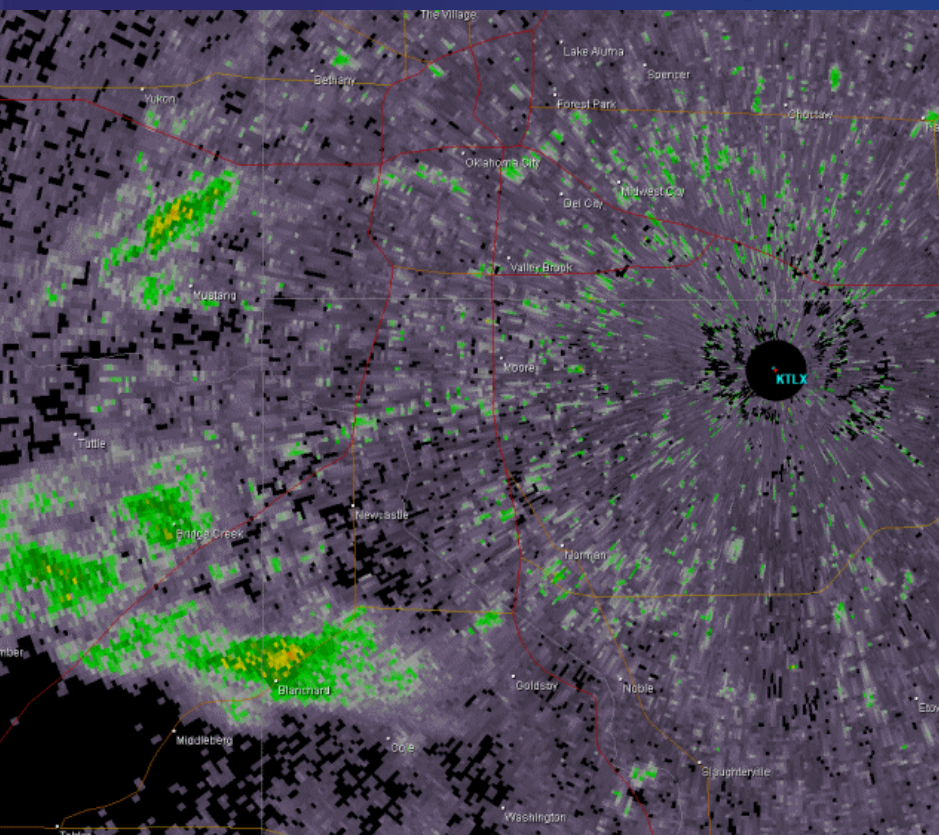


Radar Loops



Base Reflectivity

Storm Relative Velocity



May 20, 2013 Moore, OK



Tornado





Ratings & Types of Tornadoes

- Enhanced Fujita Scale (EF 0 to EF 5)
- Classic, Wedge, and Rope
- Injuries & fatalities can occur with each type.
- NWS does NOT need to know what type of tornado you are observing.



Enhanced Fujita Scale

Rating Tornadoes

EF 0	65-85 mph
EF 1	86-110 mph
EF 2	111-135 mph
EF 3	136-165 mph
EF 4	166-200 mph
EF 5	Over 200 mph

Relative Frequency

53.5% (weak)

31.6% (weak)

10.7% (strong)

3.4% (strong)

0.75% (violent)

<0.1% (violent)



Tornado – note extent of condensation funnel; debris-spray at ground



Tornadoes – note extent of condensation funnel; debris-spray at ground



Tornado



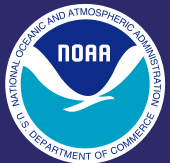
Note – condensation funnel not touching ground
Video



Wisconsin Tornado Stats



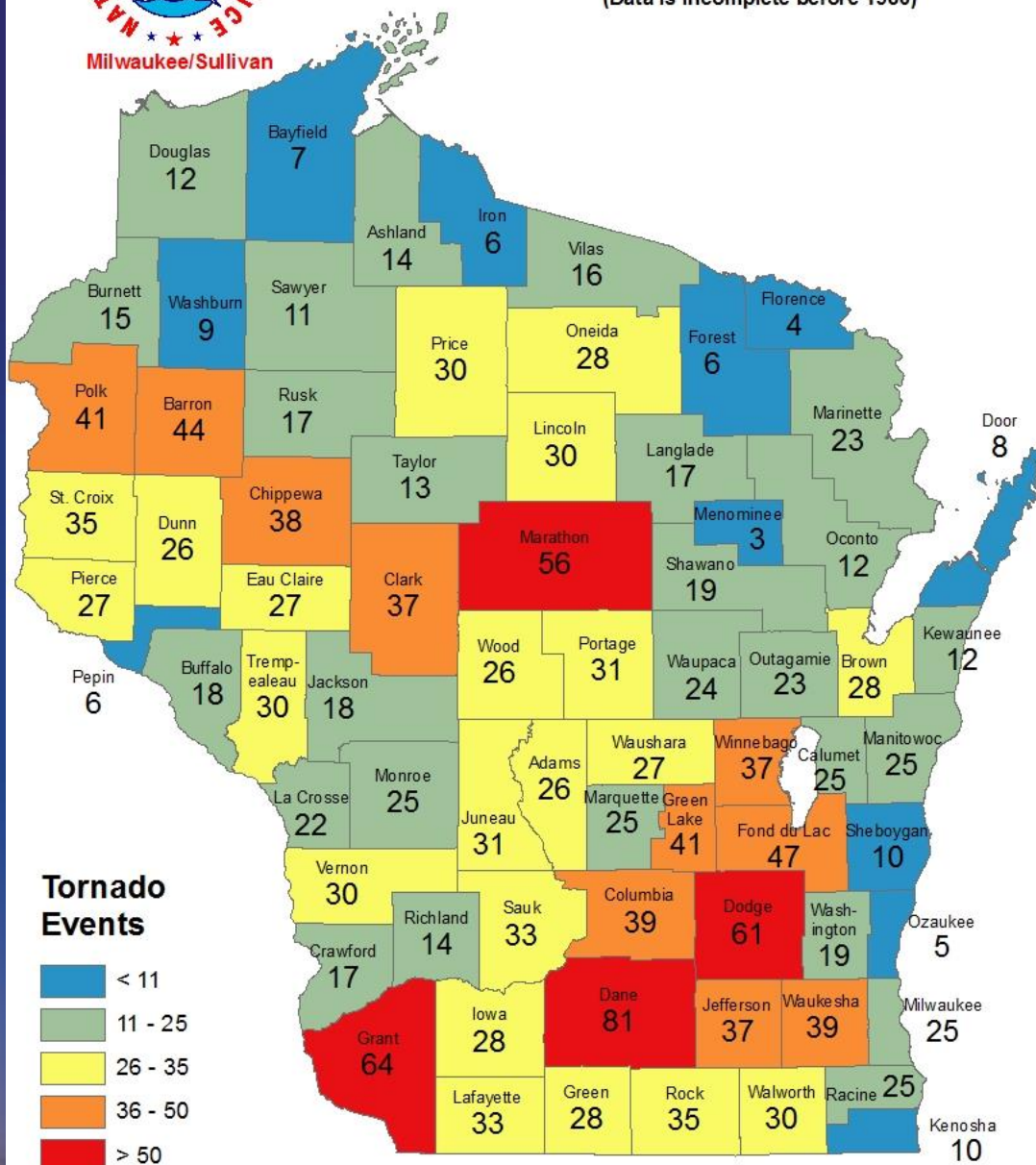
- Most tornadoes spin up between 3 pm and 9 pm, with 6-7 pm being the busiest.
- Most tornadoes occur between April and September, with June being the peak month.
- Tornadoes generally move southwest to northeast, but west to east, and northwest to southeast movements are quite possible.



Wisconsin Tornados

1844 - 2014

(Data is incomplete before 1950)

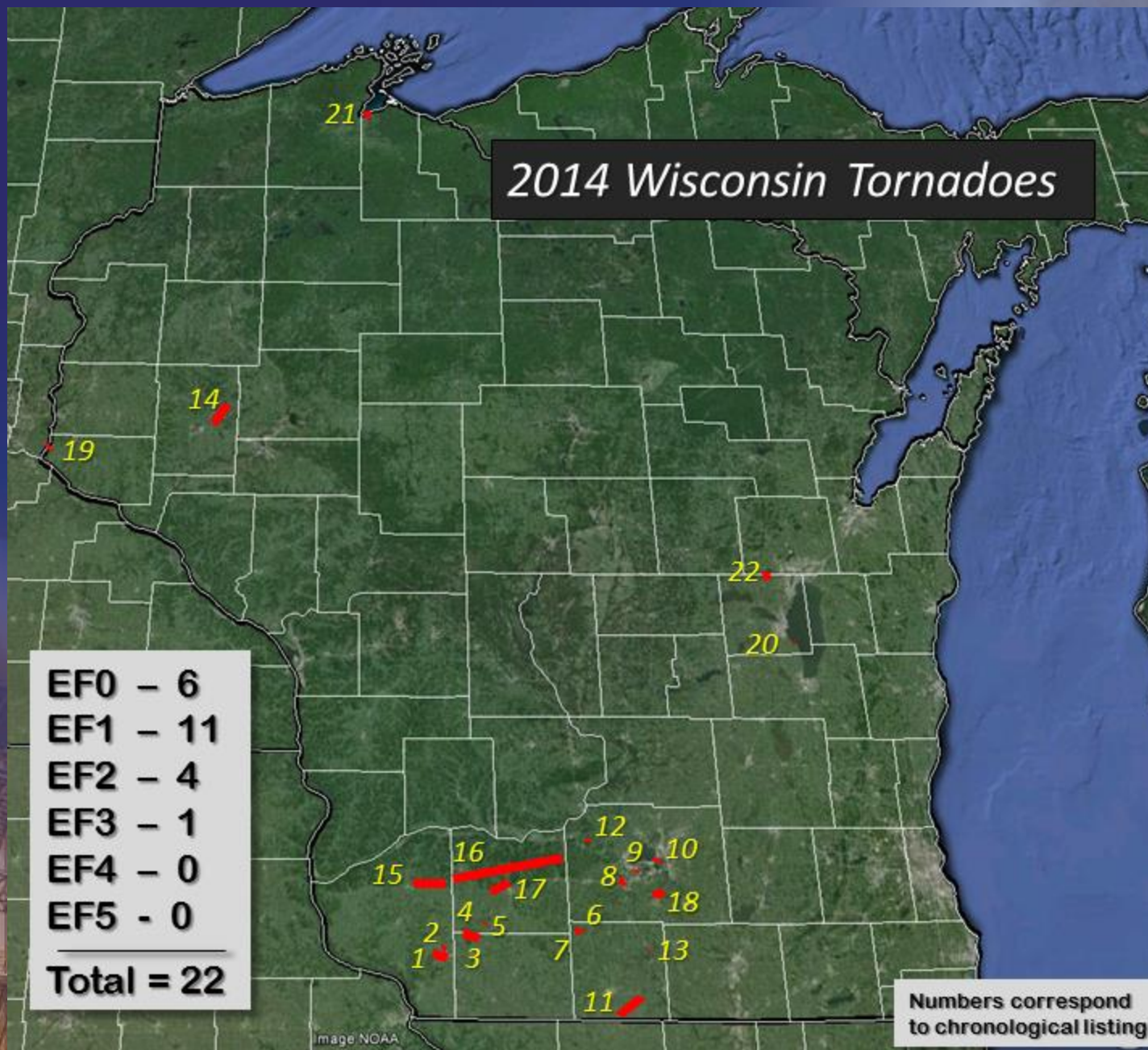




2014 Wisconsin Tornadoes

EF0 - 6
EF1 - 11
EF2 - 4
EF3 - 1
EF4 - 0
EF5 - 0

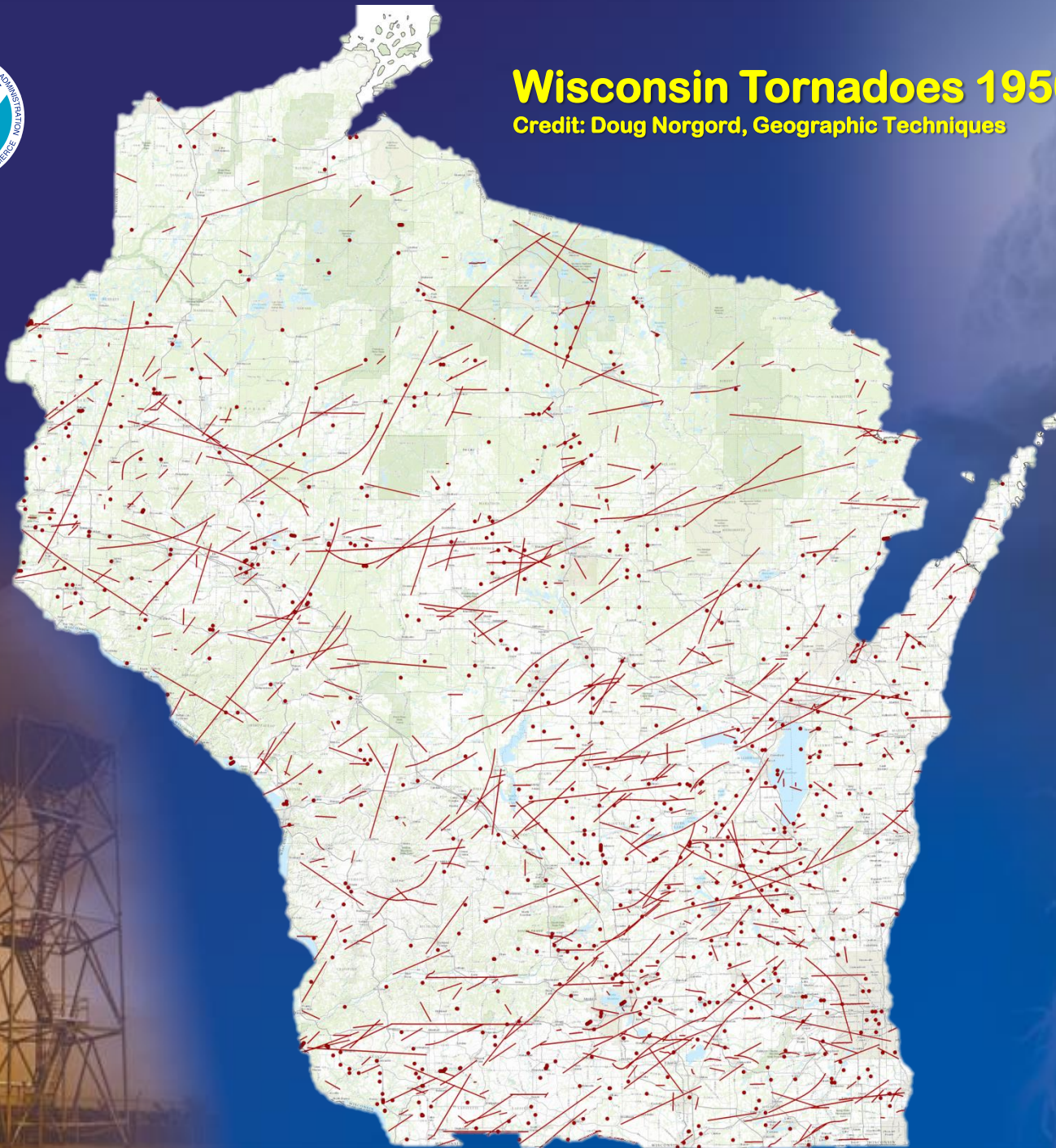
Total = 22





Wisconsin Tornadoes 1950-2014

Credit: Doug Norgord, Geographic Techniques





Personal Safety



Video

This was a weak tornado – what about a strong or violent tornado?

Personal Safety

NWS does not encourage storm chasing.



Personal Safety





How Radar Works



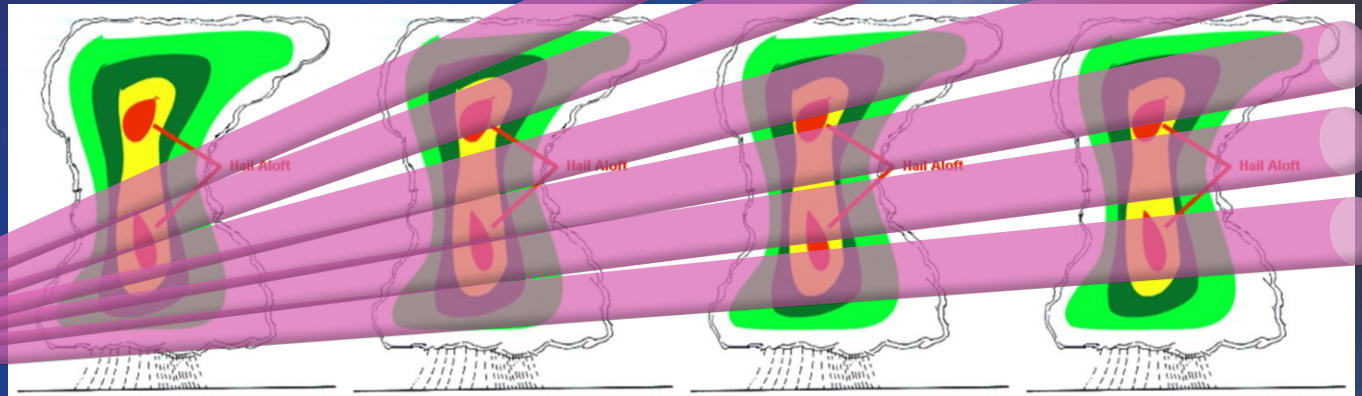
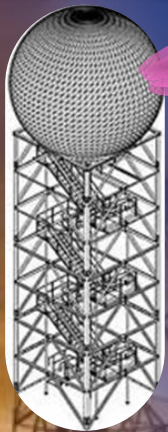


How Radar Works





How Radar Works

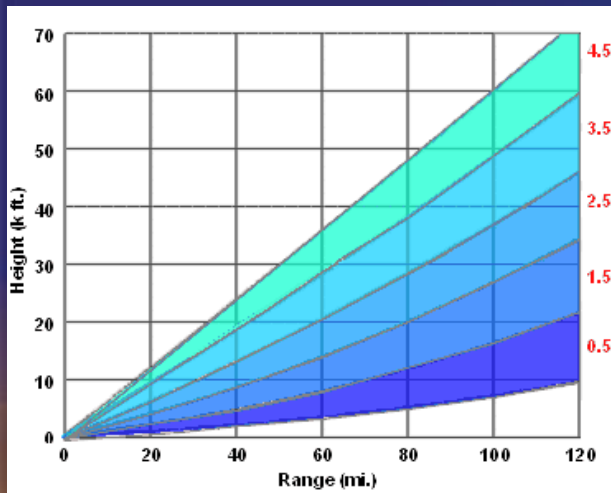


Base Reflectivity

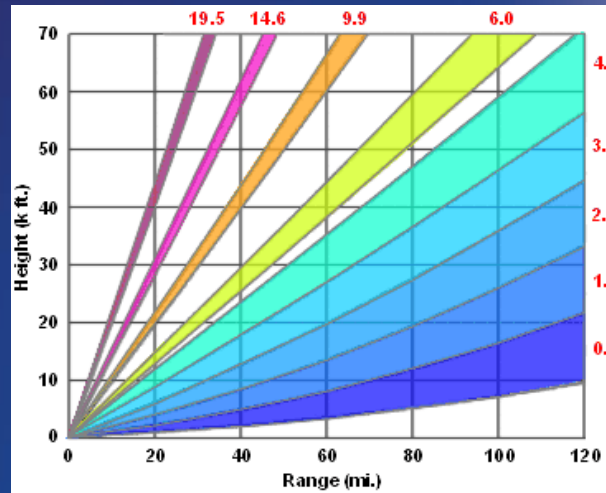




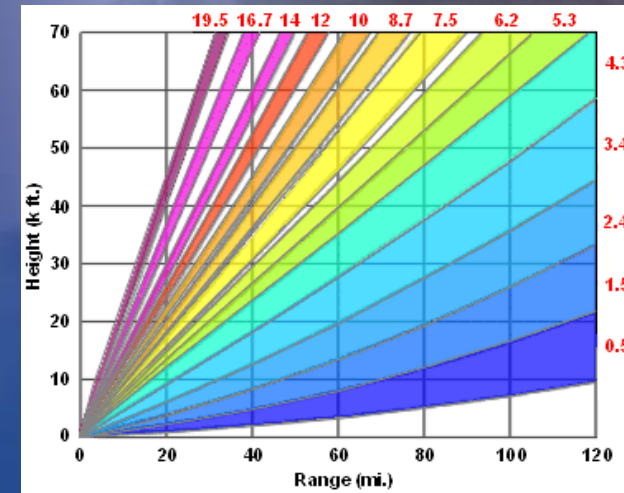
Radar Sampling Patterns



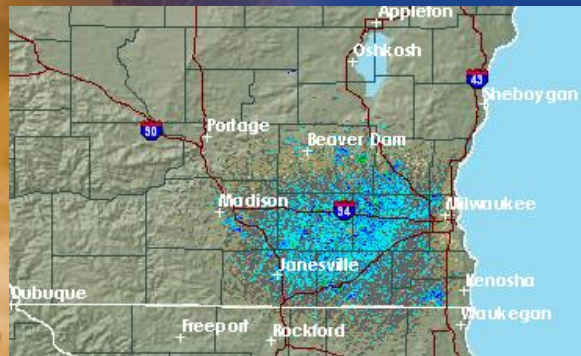
Clear Air Mode
~ 2 min per elevation



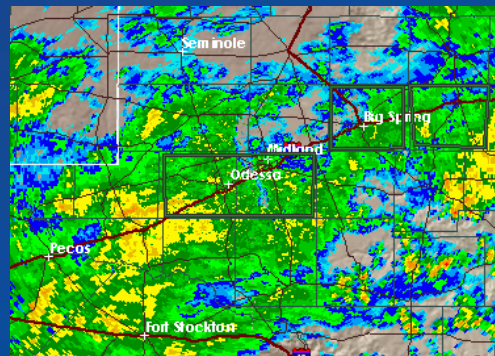
Precip Mode
~ 1 min per elevation



Storm Mode
~ 30 sec per elevation



10 minutes



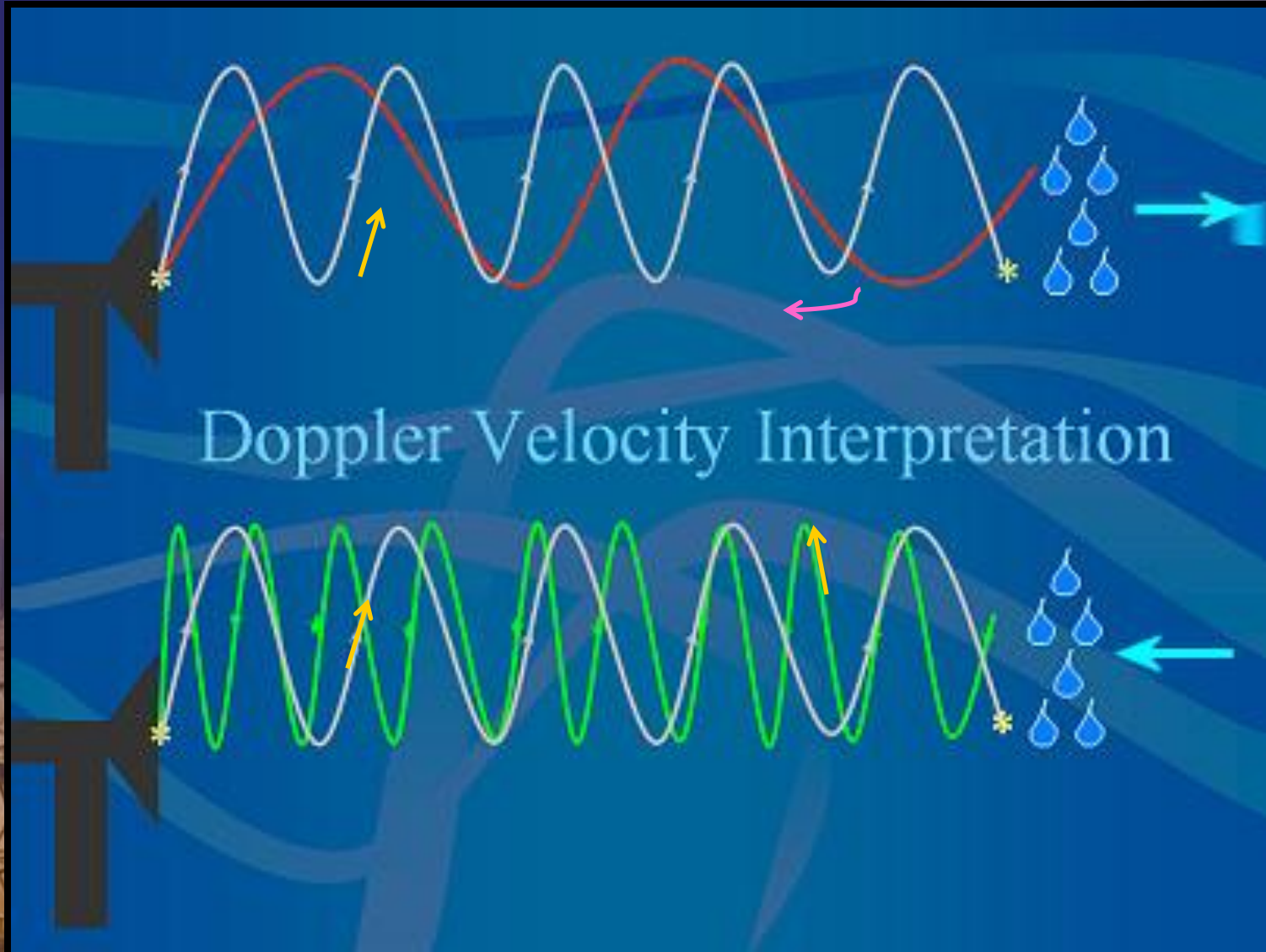
5 - 6 minutes



4 - 5 min → 2 - 3 min



Radar Velocity

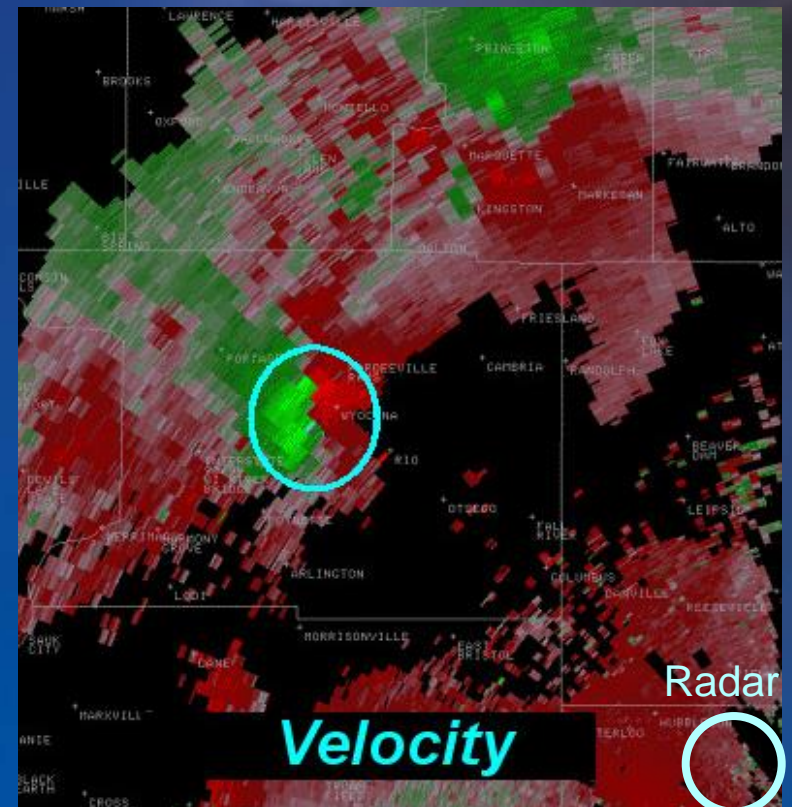
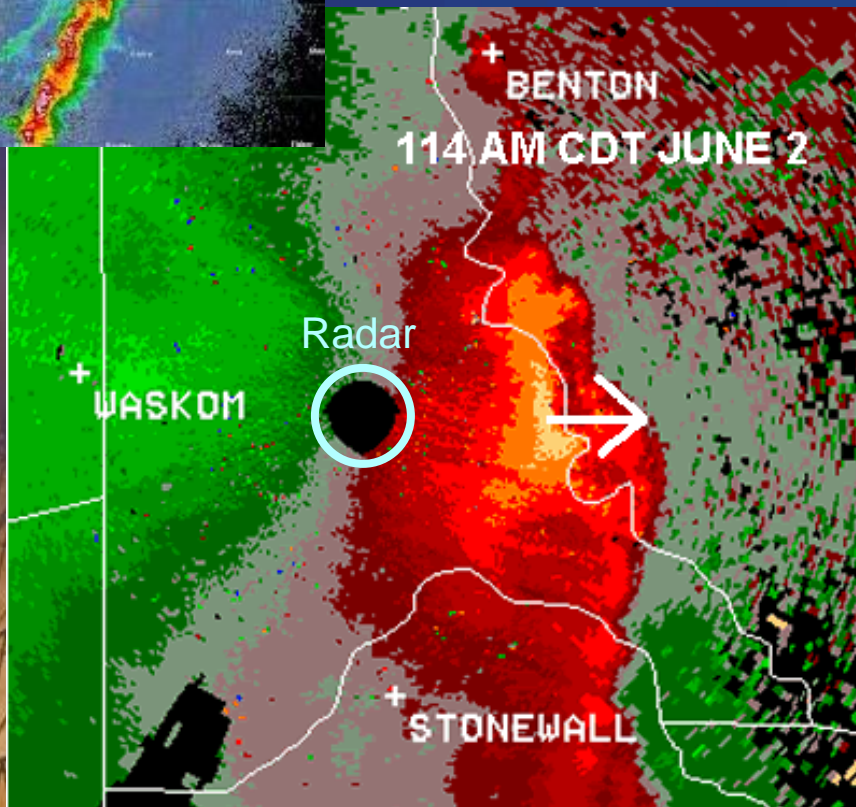
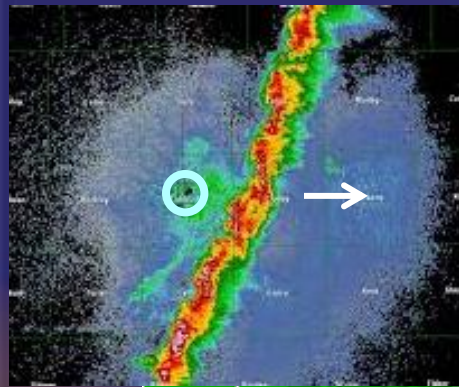




Radar Velocity Interpretation



- Green: Toward the radar
- Red: Away from the radar



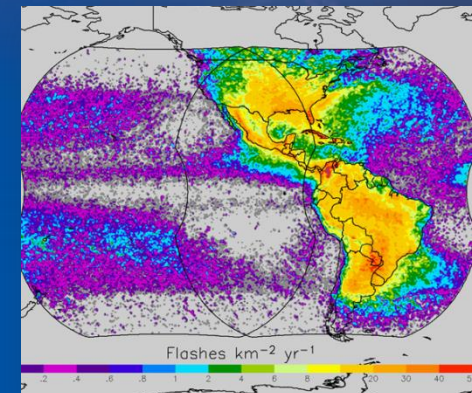


GOES - R



- First satellite launch set for March 2016
- Significant improvements in detection and observation of environmental phenomena
 - *Higher resolution, more frequent satellite images*
 - *Lightning Mapper – maps total lightning (in-cloud and cloud to ground) activity continuously 24/7*
 - Increased lightning information results in potential for improvement in tornado warning lead time

www.goes-r.gov





El Reno Tornado



- **National Weather Radar Testbed (NWRT)**
Phased Array Radar
 - *May 31, 2013*
 - *1-minute resolution depicts the fluid motion of supercell development*
 - *Path along the Interstate*

www.nssl.noaa.gov/tools/radar/mpar





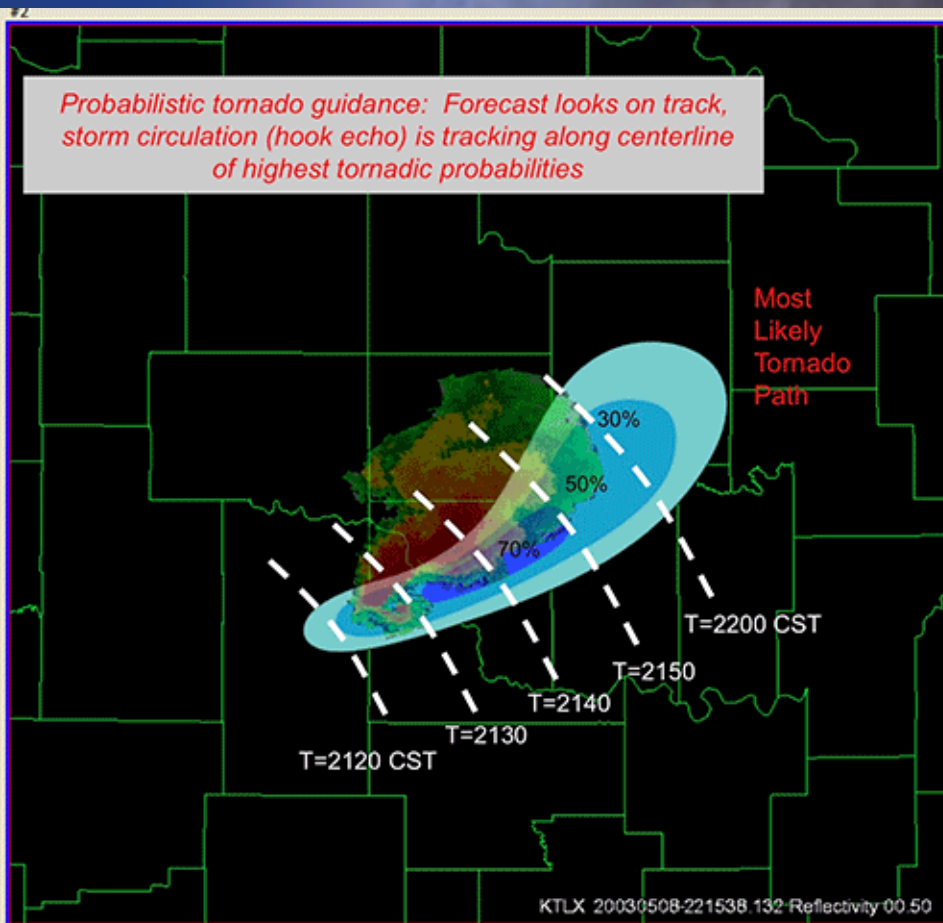
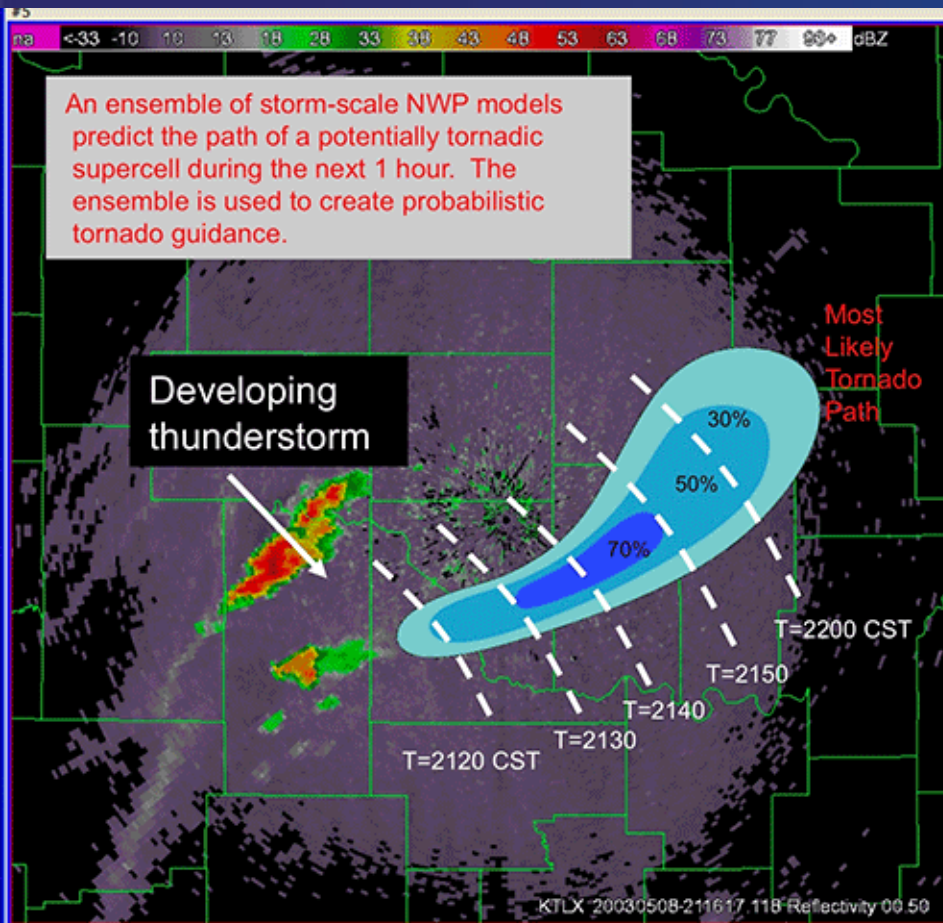
Warn-on-Forecast

- **Currently, warning process based upon warn-on-detection approach**
- **Reaching a plateau in lead time**
- **Ensemble of storm-scale numerical weather prediction models**
- **Probabilistic hazard guidance**

www.nssl.noaa.gov/projects/wof



Warn-on-Forecast



www.nssl.noaa.gov/projects/wof



The End



Questions?

